HETEROGENEOUS ENHANCED LEACH PROTOCOL IN WIRELESS SENSOR NETWORK TO PROLONG NETWORK LIFETIME WITH STATIC CLUSTERING

CHANDRA PRAKASH VERMA[1] & NEETU SHARMA[2]

[1]Student, Government Engineering College, Ajmer, Rajasthan, India

[2]Assistant Professor, Government Engineering College, Ajmer, Rajasthan, India

ABSTRACT

The research on WSN (wireless sensor networks) has recently received attention by an advantage of monitoring different kinds of simulation or application environments by sensing their physical phenomenon. Sensor nodes can somehow be related to embedded systems, in terms of application specific and their limited components. There are some important parameters are like energy efficient data packet delivery, No. of dead nodes, prolonged network lifetime, scalability, and data delivery time for every sensor network applications. Clustering in sensor nodes is a very effective and efficient technique for achieving these parameters. In this work, an algorithm is prototyped. This algorithm is an enhanced LEACH protocol that enhances the lifetime and reducing the energy consumption when compared with the existing routing protocols. The protocol is based on existing E3PSC protocol which uses the concept of static clustering. So this paper shows significant improvement in network lifetime, throughput and no. of alive nodes using enhanced protocol with compared to existing protocols.

KEYWORDS: WSN, Network Life-Time, LEACH, Clustering, Data Delivery Time, E3PSC

INTRODUCTION

Wireless sensor networks are special type of ad-hoc networks which may operate in single-hop or multi-hop ad-hoc networks. The ideal wireless sensor network is densely populated and scalable, consumes very little power, is smart and software programmable, reliable and accurate over the long term, affordable cost to purchase and install, and requires no real maintenance. Selecting the optimum sensors and wireless communications link requires knowledge of the application and problem definition. Battery life, sensor update rates, and size are all major design considerations. Examples of low data rate sensors include temperature, humidity, and peak strain captured passively. Examples of high data rate sensors include strain, acceleration, and vibration. Wireless sensor networks are application specific and the sensor devices are manufactured by various companies. It is not feasible while designing a sensor device that the various components are not efficiently working as whole unit. In order to remove this limitation, IEEE and NIST have worked together by producing IEEE 1451 standard [1] for sensor networks that describe the open, common, network independent communications interfaces for connecting sensors and actuators to the processing unit, instrumentation systems etc. The major components of smart sensors are STIM, TEDS, TII and NCAP as shown in figure 1. The main motive was to make the system cost effective in order to integrate and maintain distributed sensor networks and interfacing different types of sensors smoothly [1] [2].
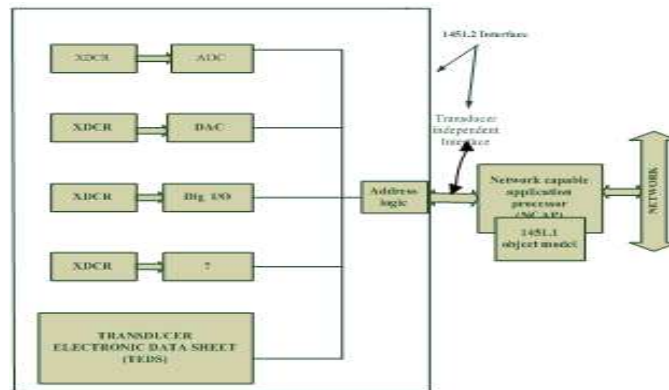
Figure 1: IEEE 1451 Standard Architecture for Smart Sensor Networks

LITERATURE SURVEY

Akyildiz et al. (2002) described a review based survey in detail about the wireless sensor networks. It is a review paper but gives basic idea about the sensor networks. It explains the embedding of MEMS technology with radio communication on the microprocessor boarded chips. This paper gives clear idea about the sensor node characteristics, features and also vast area of applications. This paper also provides thorough idea about energy utilization in WSNs.

Routing algorithms in wireless sensor networks has been classified in three main types [3]:

- Flat routing

- Hierarchical routing

- Location based routing

Heinzelman et al., (1999) proposed Sensor Protocols for Information via Negotiation in which before actual data transmission can take place it uses meta-data via communicating between sensors as an advertisement mechanism. Whenever any nodes receives data it advertises(ADV) it to neighbours, and only interested neighbours can respond by sending request message(REQ) .Then node with data can forward data(DATA) to the requested nodes. It removes the problem of flooding such as redundant information passing and overlapping of sensed areas, thus enhancing the energy efficiency. The main limitation of SPIN data advertisement is that it cannot guarantee of data delivery mostly in case of far away nodes.

LEACH [4] was first hierarchical energy efficient protocol and acts as an inspiration for others hierarchical routing protocols which came after LEACH. We will discuss various important hierarchical protocols in this section.

Low Energy Adaptive Clustering Hierarchy (LEACH) for wireless sensor networks. It is first energy efficient routing protocol for hierarchical clustering. It increases the network life by reducing the overall energy consumption of WSNs. In LEACH Protocol clusters are formed and for each cluster, a Cluster head is selected in a random way. The non cluster head nodes sense the data and forward it to cluster heads. The cluster heads aggregate the received data and the forward the data to the sink. This aggregation process reduces the transmission of redundant data. Cluster heads change randomly over time in order to balance the energy dissipation of nodes. This decision is made by the node choosing a random number between 0 and 1. The node becomes a cluster head for the current round if the number is less than the following threshold:

$$T(n) = \begin{cases} \dfrac{P}{1-p*\left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

Where P= the desired percentage of cluster heads (e.g. P=0.05), r= current round G= set of nodes that have not been the cluster heads in last1/P rounds.

M. Younis et al., (2002) proposed An Energy Aware Routing scheme called EAR. In Energy-aware routing nodes are grouped into clusters. Cluster heads namely gateways are less energy constrained nodes. Gateways maintain the states of the nodes and sets up multi hop routes. Sink only communicates with the gateway. Gateway informs other nodes about in which slot they should listen other's transmission and in which slot to carry the transmission of sensed data. The sensor can be in four states; sensing only, relaying only, sensing-relaying and inactive. A cost function is defined between any two nodes in terms of energy consumption, delay optimization and other performance metrics. Using this cost function, a least-cost path is found between sensor nodes and the gateway.

S. Lindsey et al., (2002) have proposed Power Efficient Gathering in Sensor Information Systems (PEGASIS) protocol. It is an enhanced version of LEACH protocol. That is a chain based protocol provides improvement over LEACH algorithms. Each node aggregates the collected data with its own data and then passes the aggregated data to the next node in the chain and finally to the designate node which transmits it to BS. Using greedy algorithm, the nodes will be organized to form a chain, after that BS can compute this chain and broadcast it to all the sensor nodes. Energy saving in PEGASIS over LEACH takes place by many stages [Al-Karaki et al.]: First, in the local data gathering, the distances that most of the sensor nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, only one node transmits to the BS in each round of communication. Also the number of transmissions to BS is reduced. It employs multi hop transmission and selecting only one node to transmit the data to the sink or base station while in LEACH it uses single hop. Since the overhead caused by dynamic cluster formation is eliminated.

Energy constraint is the main challenge in wireless sensor network in comparison to its vast application area. Thus most of the research is done in preserving the limited battery power of the sensor nodes. The researchers have proposed different classification of routing protocols like, flat routing hierarchical routing and location based routing etc. Hierarchical (clustering) routing protocols are the mostly energy efficient routing techniques in WSNs. We have reviewed various clustering protocols which have shown good performance in enhancing the network lifetime of the whole wireless sensor network. Heterogeneity plays vital role in enhancing further the network life time of the existing homogeneous WSNs. In next chapter we are considering the most energy efficient existing routing protocol with some modifications like availability of some fraction of nodes with more energy level than other normal nodes and location of BS within the deployed area of the sensor nodes.

PROPOSED ALGORITHM

Our proposed protocol is based on the existing energy efficient protocol which outperforms various other routing protocols in WSNs. As we are working on heterogeneous networks, our preliminary objective must be to analyze effect of heterogeneous nodes in other existing protocols.

Research design basically refers to the framework that provides the detail about the different procedures, methods by obtaining the data and information of the research problems and to structure, solve the research problems. There are

number of research designs available for the different research problems.

- **Null Hypothesis**: Ho= our proposed protocol, H-E3SPC is based on existing E3SPC algorithm. With help of heterogeneous nodes our algorithm enhances the network lifetime and the throughput of the whole network in comparison to the existing routing protocol in wireless sensor networks.

- **Alternate Hypothesis**: H1= the proposed algorithm will not be economical in enhancing the energy of existing protocol in wireless sensor networks.
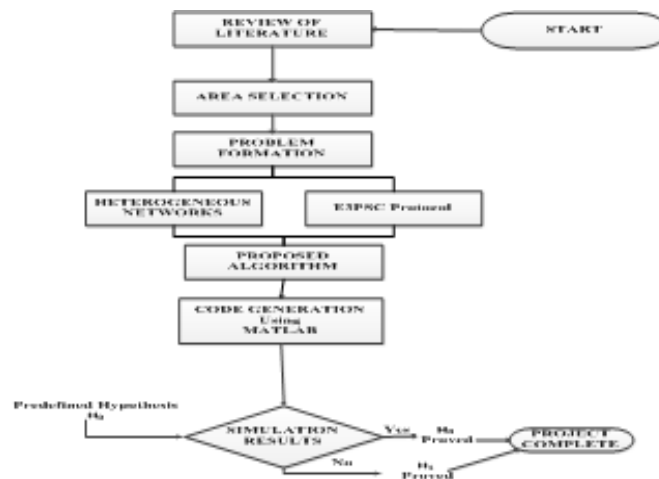

Figure 2: Flowchart of Our Research Methodology

H-E3PSC (Heterogeneous-Enhanced Energy Efficient Protocol with Static Clustering)

We designed an energy efficient routing protocol which is based on existing E3PSC in wireless sensor networks. E3PSC is based on static clustering in which BS initially makes decision about the clusters in the whole network area. E3PSC has significantly enhanced the network lifetime and throughput of the whole network as compared to other existing energy efficient hierarchical routing protocols. The throughput of E3PSC algorithm is significant as experimental results has shown that after receiving 16157 messages at BS and there exist at least 40 nodes which are still alive. The network lifetime of the WSNs can be further significantly enhanced by placing a fraction of nodes uniformly in the clusters in WSNs are deployed mostly in the region far way from base station location. The proper location of BS plays an important role in enhancing the network lifetime and the reduction of early death of nodes in the networks. Thus BS is placed with the network area of the deployed field of all the sensor nodes such that each node as the CH can transmit the packets in best possible throughput.

Algorithm

/***Setup Phase */**

- START

/* In **Setup Phase** the tasks are performed and initiated by Sink */

- INITIALIZATION

k is desired number of clusters initially set by the Base station with n total number of sensor nodes from these n nodes we take fraction of nodes m having α times more energy than normal nodes.

Sink transmits *k-1* messages with different transmission powers one-by-one. And the sensor nodes responds to the successive messages will form various clusters.

- For i $\leftarrow$ 1 to k

- Compute mean position of node-distribution, **P mean$_i$** in **cluster$_i$**

- For j $\leftarrow$ 1 to s$_i$ /* s$_i$=No. of nodes in cluster i */Compute distance of node$_j$ from **P mean$_i$** $\rightarrow$**d$_{mean}^j{}_i$**

- End for loop

- Select Temporary Cluster Head (TCH$_i$) randomly for **cluster$_i$**

- Create TDMA schedule for the all nodes of **cluster$_i$**

- For j$\leftarrow$ 1 to **s$_i$**

- Send (**TCH$_i$, TDMA$_i$, d$_{mean}^j{}_i$**) data to **node$_j$**

  /*control information to every node in every*/ cluster.

- End For loop

- End For loop

  /* End of **Setup Phase */**

- for v$\leftarrow$1 to round

  /* round Total number of rounds */

  /* **Responsible Node Selection Phase */**

- For i$\leftarrow$ 1 to k

- for Alive_node$\leftarrow$1 to **s$_i$**

  /* Alive_node Nodes whose residual energy is greater than or equal to threshold energy (E$_{trsh}$)

- Send (**d$_{mean}^j{}_i$, E $_{residual}^j{}_i$**) information to TCH$_i$

- End For

  /* TCH$_i$ performs following tasks */

  . Call Responsible_Node_Selection ( )

  /* Select **CH$_i$** for the current round and **TCH$_i$** for next round */

- End For loop

  /* **Steady State Phase */**

- For i$\leftarrow$1 to k

- For Alive_node $\leftarrow$ 1 to **s$_i$**

- Send data to **CHᵢ**

  /* Data transmission by Alive_nodes */

- End For loop

- Send aggregated data to Sink/Base station

  /* Data transmission by **CHᵢ** */

- End For loop

- End For loop

- END

Responsible_Node_Selection ( )

- BEGIN

- for i←1 to k

- Weight= [ ]

- for j←1 to **si**

- Weight = [weight, **E**residualji /**d**meanji]

- End for loop

- CHi = Alive_node with maximum value of [Weight]

- TCHi = Alive_node with second maximum value of [Weight]
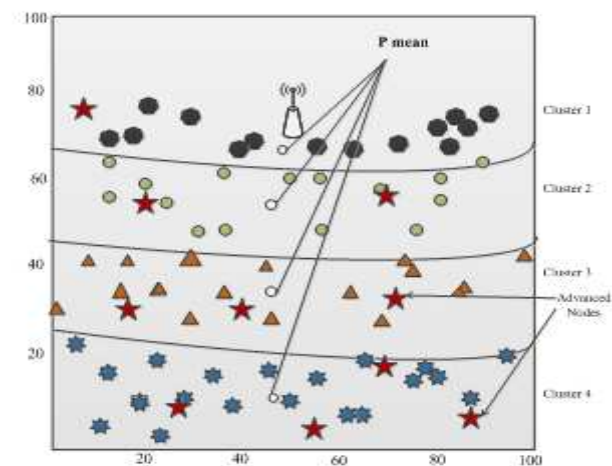
- End for loop

- END

  /* End of the Algorithm*/

Figure 3: Deployment of WSN with Advanced Nodes in Our Protocol

RESULTS AND DISCUSSIONS

There are various tools which are specifically developed for simulating a wireless sensor network for example OMNET++ & Castalia, Network Simulator 2 and MATLAB. We are working on performance of the energy efficient routing protocols in wireless sensor networks in MATLAB. Since efficiency of routing algorithms in WSNs are measured through various performance metrics like Network Lifetime, throughput and the number of dead nodes found during whole network operation. These performance metrics can be performed in MATLAB with higher accuracy. As MATLAB is widely used tool for executing the programming code with some graphical representations but provides with numerical results in easily understandable graphs.

Parameters Used in Simulation for Existing E3PSC

Table 1: Parameters Used in Simulation of Existing E3PSC

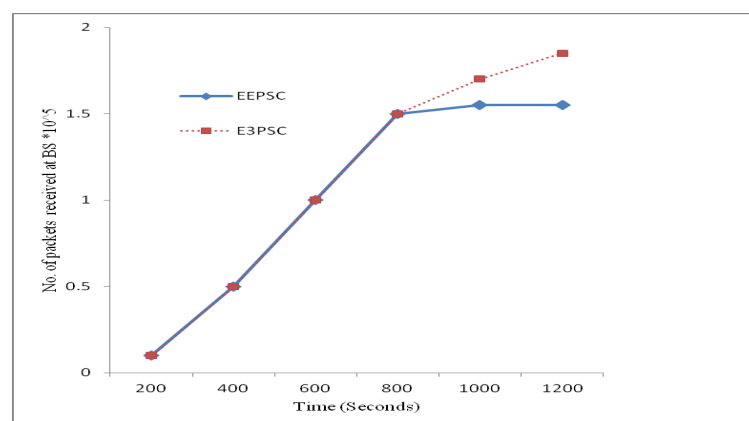| Parameter	Parameter's value
Network Area	100×100 meters
Base station's Position	(50m,175m)
Initial Energy for Nodes	2 joules
Number of Nodes deployed	100
Size of Data Message	4000bits
Energy Consumed in Data Aggregation (E_{DA})	5nJ/bit/signal
Energy Consumed by Transceiver's Circuitry (E_{elec})	50nJ/bit
Energy Expenditure in Transmit-Amplification in free space mode (ε_{fs})	10pJ/bit/m^2
Energy Expenditure in Transmit-Amplification in multipath fading model(ε_{mp})	0.0013pJ/bit/m^4

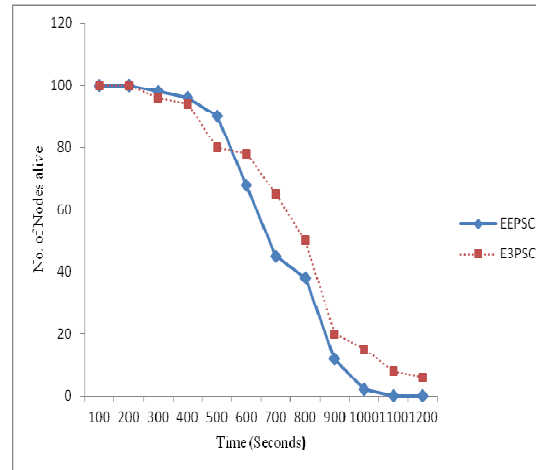**Figure 4: Number of Messages Received at BS Over Time**

Figure 5: Number of Nodes Alive Over Time

Parameters Used In Simulation for Prototyped H-E3PSC

Table 2: Parameters Used in Simulation of Prototyped Algorithm H-E3PSC

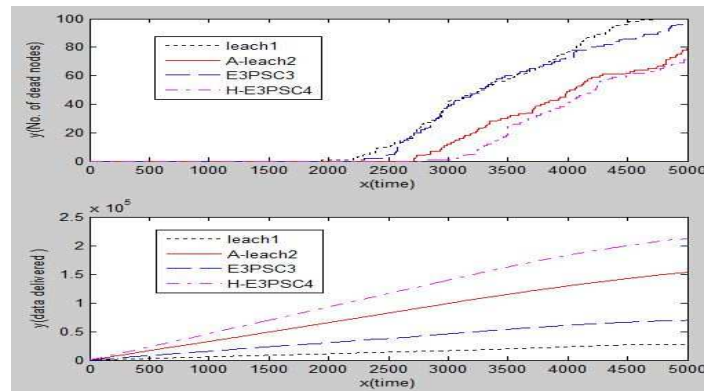| Parameter	Parameter's Value
Network Area	100×100 meters
Base station's Position	(50m,75m)
Initial Energy for Nodes(Eo)	1,2 joules
Number of Nodes deployed	100
Size of Data Message	4000bits
Energy Consumed in Data Aggregation (EDA)	5nJ/bit/signal
Energy Consumed by Transceiver's Circuitry(Eelec)	50nJ/bit
Energy Expenditure in Transmit-Amplification in free space mode(εfs)	10pJ/bit/m^2
Energy Expenditure in Transmit-Amplification in multipath fading model(εmp)	0.0013pJ/bit/m^4
Value of heterogeneity (%age of nodes m than are advanced with α energy more than normal nodes)	m=0.1(10%); α =1,2;

Figure 6: Number of Dead Nodes Found Over Period of Simulation Time (Seconds)
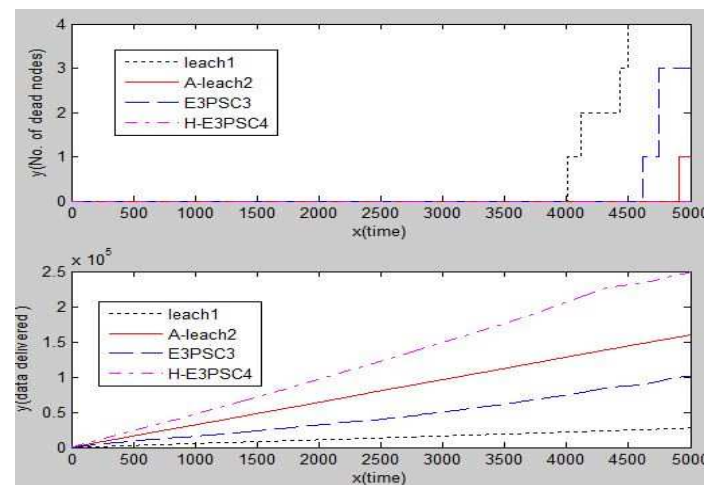

Figure 7: Number of Data Packets Delivered To BS over Time (Seconds)

Observations

- No overhead due dynamic clustering as the optimal number of clusters are initially specified by BS

- BS is located within the deployed area of WSN, which results in less number of dead nodes in the clusters which are far away from the BS.

- The network lifetime of the whole WSN has shown significant improvement our existing protocol.

- When E_o=1 and α=1, The first nodes dies after 2816 rounds while in existing protocol the first node dies after 2249 rounds. Thus more number of nodes are alive in our protocol which will helps in preserving the energy of sensor nodes to maximum extent. In other case when E_o=2 and α=2, the results show significant improvement i.e. the first dead nodes exist after 5000 rounds .thus heterogeneity plays vital role in enhancing the network lifetime.

- The number of packets received by BS in E3PSC protocol during the whole simulation time was 69475 while it shows significant enhancement in delivery of packets to BS in our protocol are 211899.

- The throughput of existing protocol about .25 while the throughput of our protocol is approximately approaching to unity.

- There is concentration of more number of alive nodes in our proposed protocol than existing protocols.

CONCLUSIONS AND FUTURE WORK

In this paper it has been prototyped an energy efficient routing protocol for wireless sensor networks in which the battery power of the sensor nodes is of limited capacity and cannot be replaced. The protocol is based on existing E3PSC protocol which uses the concept of static clustering and the selection of cluster heads on the basis of highest energy of the nodes and the minimum distance from the average node distribution in every cluster. By taking the fraction of nodes which are having more energy than normal nodes and these advanced nodes are placed uniformly in the network region mostly in the clusters which are away from the BS. The simulation results have shown that better results in enhancing the lifetime and reducing the energy consumption when compared with the existing routing protocols. There is still room for further enhancement in our protocol by which the energy can be conserved in order to prolong the network lifetime and simultaneously the optimal throughput of the network. This can be achieved by transmitting the data from sensor nodes to CHs in their own clusters and then CHs communicate in multi-hop fashion to finally deliver the data to the BS.

REFERENCES

1. Frank L. Lewis, "Wireless Sensor Network", Smart Environments: Technologies, Protocols, and Applications, New York, 2004.

2. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, "Wireless Sensor Network: A Survey", Computer Networks, Elsevier, pp 393-422, 2002.

3. J. N. Al-Karaki and A. E. Kamal, "Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Wireless Communication Vol.11, No.6, pp. 6-28, Dec.2004.

4. W. R. Heinzelman, A. P. Chandrakasan and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Microsensor Networks", in Proceedings of Hawaii International Conference on System Sciences, Vol. 8, pp. 1-10, Jan. 2000.

5. W. R. Heinzelman, A. Chandrakasan and H. Balakrishnan, "An Application-Specific Protocol Architecture for Wireless Microsensor Networks," IEEE Transactions on Wireless Communications, Vol. 1, No. 4, pp. 660-670, Oct. 2002.

6. W. R. Heinzelman, J. Kulik, and H. Balakrishnan, "Adaptive Protocols for Information Dissemination in Wireless Sensor Networks," in Proceedings of the 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom '99), Seattle, WA, pp. 174-85. August, 1999.

7. HAN Hong-quan, ZHU Hong-song, MENG Jun, The wireless sensor network. Applications of the Computer Systems, 2005, 8(2).

8. Kumar, N. Kaur, J, "Improved LEACH Protocol for Wireless Sensor Networks," in Wireless Communications, Networking and Mobile Computing (WiCOM), 2011 7th International Conference on, Sept. 2011.

9. IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 1, September 2011 ISSN (Online): 1694-0814

10. Enhanced LEACH Protocol for Wireless Sensor Networks

11. S. Lindsey, C. Raghavendra, PEGASIS: Power-Efficient Gathering in Sensor Information Systems", IEEE Aerospace Conference Proceedings, 2002, Vol. 3, 9-16 pp. 1125-1130.

12. Locally Optimal Source Routing for energy-efficient geographic routing Juan A. Sanchez Æ Pedro M. Ruiz Published online: 1 September 2007 _ Springer Science+ Business Media, LLC 2007

13. EBRP: Energy-Balanced Routing Protocol for Data Gathering in Wireless Sensor Networks in IEEE Transactions on Parallel and Distributed Systems, VOL. 22, NO. 12, December 2011

14. Modify LEACH Algorithm for Wireless Sensor Network in IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 5, No 1, September 2011 ISSN (Online): 1694-0814

15. O. Zytoune, M. El aroussi, M. Rziza, D. Aboutajdine: Stochastic Low Energy Adaptive Clustering Hierarchy, ICGST-CNIR, Volume (8), Issue (1), (2008) pp 4751.